# 24P082-P

# Hydrogen isotope removal in ion-damaged W
照射損傷を与えたタングステン中の水素同位体除去について

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The purpose of this study is to investigate an isotope exchange phenomena to remove tritium accumulated in damaged tungsten. Tungsten specimens damaged by high energy hydrogen were irradiated by low energy deuterium ion beam, then irradiated by hydrogen ion beam. The deuterium depth profiles were measured by NRA and SIMS. Experimental results and TMAP modeling results on isotope exchange phenomena between deuterium and hydrogen were compared.

## 1. Introduction

Tungsten is one candidate for plasma facing materials (PFM's) in ITER and is planned for future fusion reactors. PFMs are simultaneously exposed to fuel particles and 14MeV neutrons generated by DT reactions. The radiation damage produced by the neutrons will increase tritium retention in tungsten due to production of hydrogen isotope trap sites. Increased tritium retention will impact safety and operational limits of ITER and future fusion reactors. Therefore, it is important to assess the trap characteristics produced in tungsten and develop the way to remove tritium trapped in these sites. It is known that annealing is one way to remove tritium. In this study, however, we study the effect of isotope exchange because it could take place at lower temperatures than annealing temperatures.

## 2. Experiment

In this study, tungsten damage were produced by high energy negative hydrogen ions (~300keV and 700keV) using MeV Test Facility (MTF) in JAEA. This energy difference makes the damage depth profiles different. All of the damaged specimens were irradiated at 473K by a low energy(~1keV) deuterium ion beam using HiFIT in Osaka Univ. to the fluence of $1.5\times10^{24}$D/m$^2$. Then the irradiated specimens were irradiated at 473K by the same energy of hydrogen ion beam to the fluence of $5.0\times10^{22}$~$1.5\times10^{24}$H/m$^2$. in order to observe removal of initially implanted deuterium by isotope exchange reactions. The deuterium depth profiles in the specimens were measured by Nuclear Reaction Analysis(NRA) and Secondary Ion Mass Spectrometry(SIMS). In our study, 300keVH damaged specimens were used to see isotope exchange only, and 700keV damaged specimens were used to see isotope exchange for trapped deuterium atoms at high energy trap sites. For the latter experiment, the samples with deuterium implanted were annealed at 573 K to desorb trapped deuterium at relatively low energy trap sites.

## 3. Result

300keV ion damaged specimens were firstly irradiated to the fluence of $1.5\times10^{24}$D/m$^2$ deuterium, which is enough for deuterium saturation at damaged region [1], followed by hydrogen irradiation to the fluences of $5.0\times10^{22}$, $1.0\times10^{23}$, $5.0\times10^{23}$, $1.5\times10^{24}$H/m$^2$. Irradiation temperature was 473K. There was no deuterium left in the specimens irradiated by hydrogen to the fluence of higher than $5.0\times10^{23}$H/m$^2$ from the SIMS data. This result suggested that isotope exchange between deuterium and hydrogen took place.

On the other hand, there should be left only strongly trapped deuterium after annealing in 700keV damaged specimens. We will present results on whether these strongly trapped deuterium are removed by hydrogen isotope exchange at the temperature where the strongly trapped deuterium are not thermally desorbed. We will also show simulation results by the TMAP7 code, which can simulation hydrogen isotope retention and diffusion in materials.

**Reference**

[1]M.Fukumoto et al., Journal of Nuclear Materials 390–391 (2009) 572–575